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TEST PLAN REPORT FOR CATAPULT FATIGUE  
TEST OF THE MODEL C-2A AIRPLANE

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Warminster, Pennsylvania

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DEPARTMENT OF THE NAVY  
NAVAL AIR DEVELOPMENT CENTER  
WARMINSTER, PA. 18974

AIR VEHICLE TECHNOLOGY DEPARTMENT

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AIRTASK NO. A510-5103/001-4/2510-000002  
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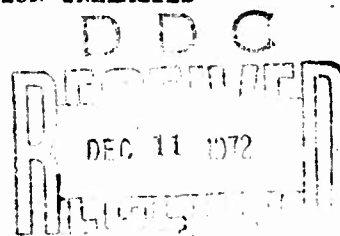
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## INTRODUCTION

The C-2A airplane, which is of the nose tow catapult configuration, was certified for 1000 catapult launches as a result of nose gear catapult fatigue tests performed by the Grumman Aerospace Corporation (GAC) in 1966. Service usage records indicate, however, that 1000 catapult launches will be grossly insufficient to satisfy projected operational requirements for this airplane. A more realistic requirement is the capability to sustain 3000 catapult launches.

Since the catapult fatigue life of the nose gear has been established by the GAC tests, the results of which are presented in reference (a), the objective of this test program is to determine to capacity of the C-2A airframe to sustain 3000 catapult launches and to determine any structural modifications necessary to achieve this life.

The objective of this test plan is to present all pertinent engineering data required to set up and perform a catapult fatigue test on this model airplane.

## SYMBOLS

Symbols used in this report are defined below:

FS - Fuselage Station  
FRL - Fuselage Reference Line  
LL - Limit Load =  $2/3$  Design ultimate load  
Re - Resultant Load

## SIGN CONVENTION

The following sign convention is used: Distances and forces are positive when they are up, aft and to the left with respect to the reference axes (See figure 1).

Positive bending moments produce compression in the top surface and left side of the fuselage. Positive vertical shear results when the positive vertical loads are summed from a station of greater magnitude to one of lesser magnitude.

Positive lateral shear results when the positive lateral loads are summed from a station of greater magnitude to one of lesser magnitude. Positive torsion about the FRL results when a station of higher magnitude rotates clockwise in relation to a station of lower magnitude when viewed from aft.

## REFERENCE AXES

x - axis: Lies in the plane of symmetry 100 inches below and parallel to the FRL

y - axis: Perpendicular to the plane of symmetry  
through the x - axis at FS 0.

z - axis: Perpendicular to the x-y plane through  
the intersection of the x and y axes.

#### BASIC DATA

Catapulting design gross weight.....54,354 pounds

Catapult test condition (Ref.(b)).....GAC Condition 11Ca Catapulting,  
Start of Run II

#### TEST PROGRAM

The program will consist of two phases, the first phase being a fatigue analysis of the fuselage in Cond 11Ca. The purpose of the analysis will be to determine if the fuselage is capable of sustaining 6000 catapult launches. If the analysis reveals any components that have a life that is substantially less than 6000 catapult launches they will be modified, if possible, during the second phase of the program. Phase two will be the laboratory fatigue test in which the test article will be subjected to the equivalent of 6000 catapult launches. The fatigue analysis and the fatigue test both include a scatter factor of two, i.e., satisfactory completion of 6000 catapult launches are required to demonstrate a service fatigue life of 3000 catapult launches.

The test article will be the C-2A fuselage that was used by GAC in their arrested landing and catapult static tests and in drop tests. During one drop test the fuselage was broken into two pieces in the forward mid section between FS 215 and FS 252. The aft section of this fuselage was used by the Naval Air Development Center in the performance of the C-2A arrested landing fatigue test as reported in reference (c). The two sections of fuselage will be spliced together and the test specimen will consist of the fuselage and wing center section. This splice will be designed to withstand the test loads but it will not be a duplicate of the original airplane structure.

During the previously mentioned static tests performed by GAC the fuselage received one application of design ultimate load (150% LL) in Cond 11Ca. It is possible that the application of this load could have produced residual stresses in the fuselage that may have a significant effect on its fatigue life. Therefore an analytical and experimental investigation will be performed by GAC in an attempt to measure this effect. After the completion of this investigation, a meeting of representatives of the Naval Air Systems Command, the Naval Air Development Center and GAC will be held to review the results of the investigation.

As a result of this meeting the catapult test program may be modified in some way to compensate for the effects of the preload.

#### TEST METHOD

The test specimen will be supported by the dummy main landing gear which will react loads in the vertical, axial and lateral directions. The airplane will be positioned so that the FRL is parallel to and 134 inches above the floor and the plane of symmetry is perpendicular to the floor.

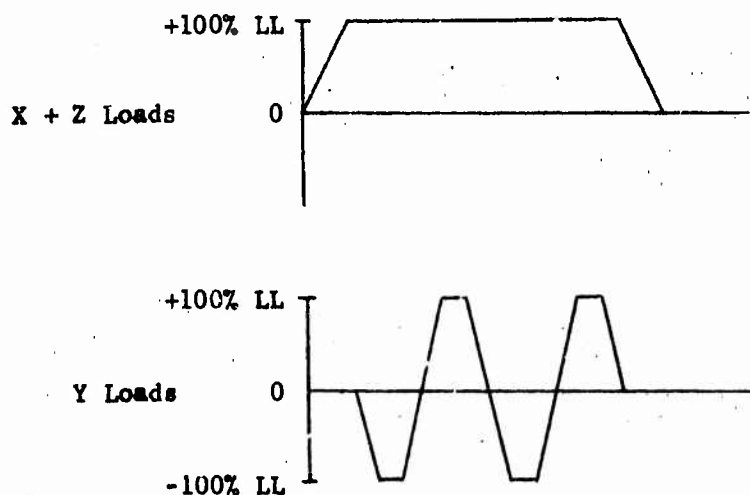
Loading of the specimen will be accomplished by an electro-hydraulic, servo controlled, closed loop loading system.

#### TEST LOADS

The magnitudes of the test loads are listed in Table 1. The balance diagram showing the locations of the applied loads and reactions is shown in Figure 2. Comparisons of the design and test curves are shown in Figures 3 through 8. These comparisons show good agreement in the critical area forward of the wing.

#### TEST SPECTRUM

The test spectrum will be the catapult spectrum of Mil-A-8867. A typical catapult test load cycle is shown below:





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Six thousand (6000) of these cycles will be applied in the test program to demonstrate the capability to withstand the effects of three thousand (3000) launches in service.

**REFERENCES**

- (a) GAC Report No. 3839.12A, Results of Nose Gear Catapult Fatigue Tests, dtd 12 Sep 1966.
- (b) GAC Report No. 3803.3A, Ground Loading Conditions, dtd 1 Sep 1963.
- (c) NADC Report NADC-ST-7111 Arrested Landing Fatigue Test of Model C-2A Airplane dtd 30 Jun 1971.

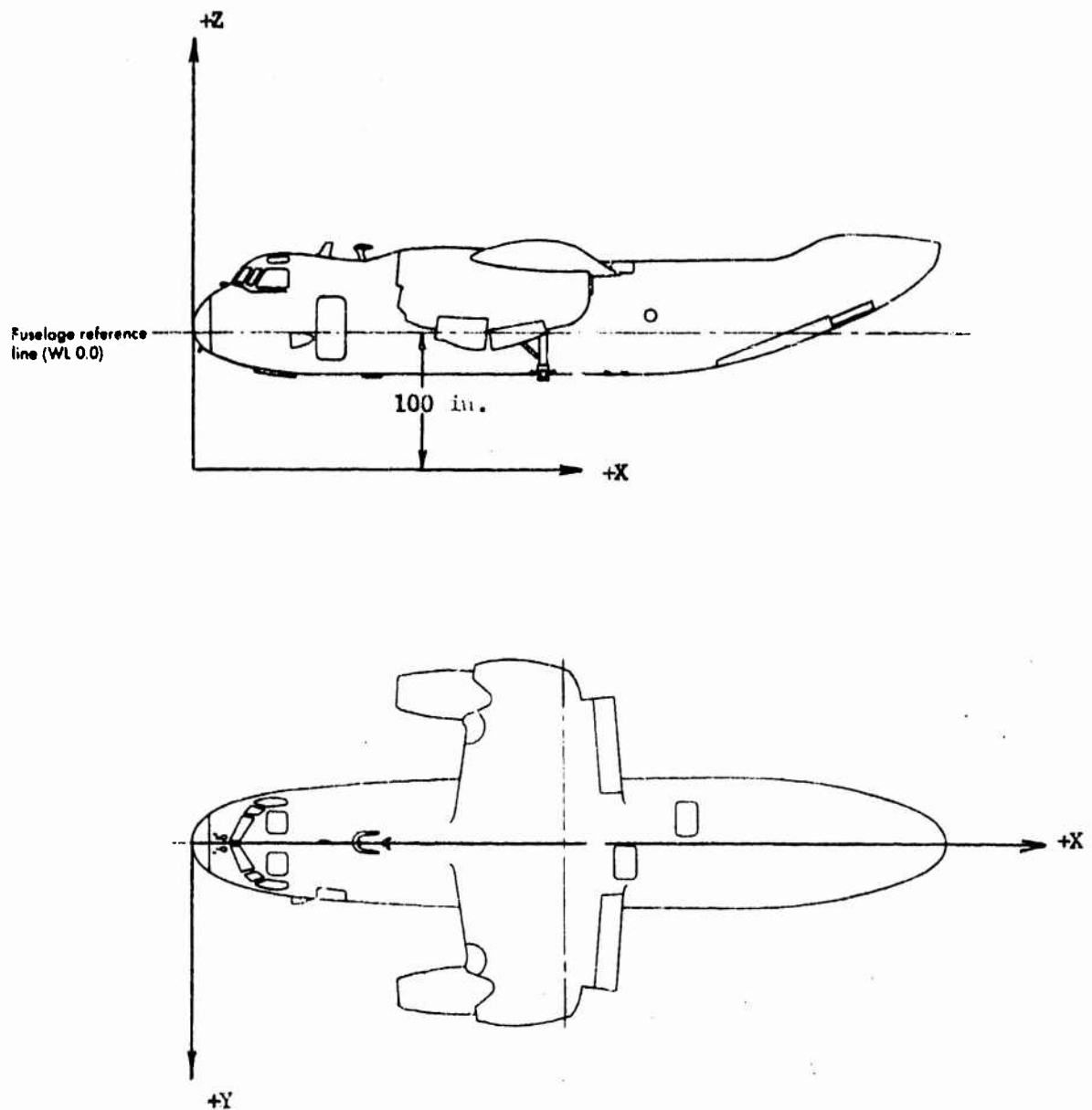
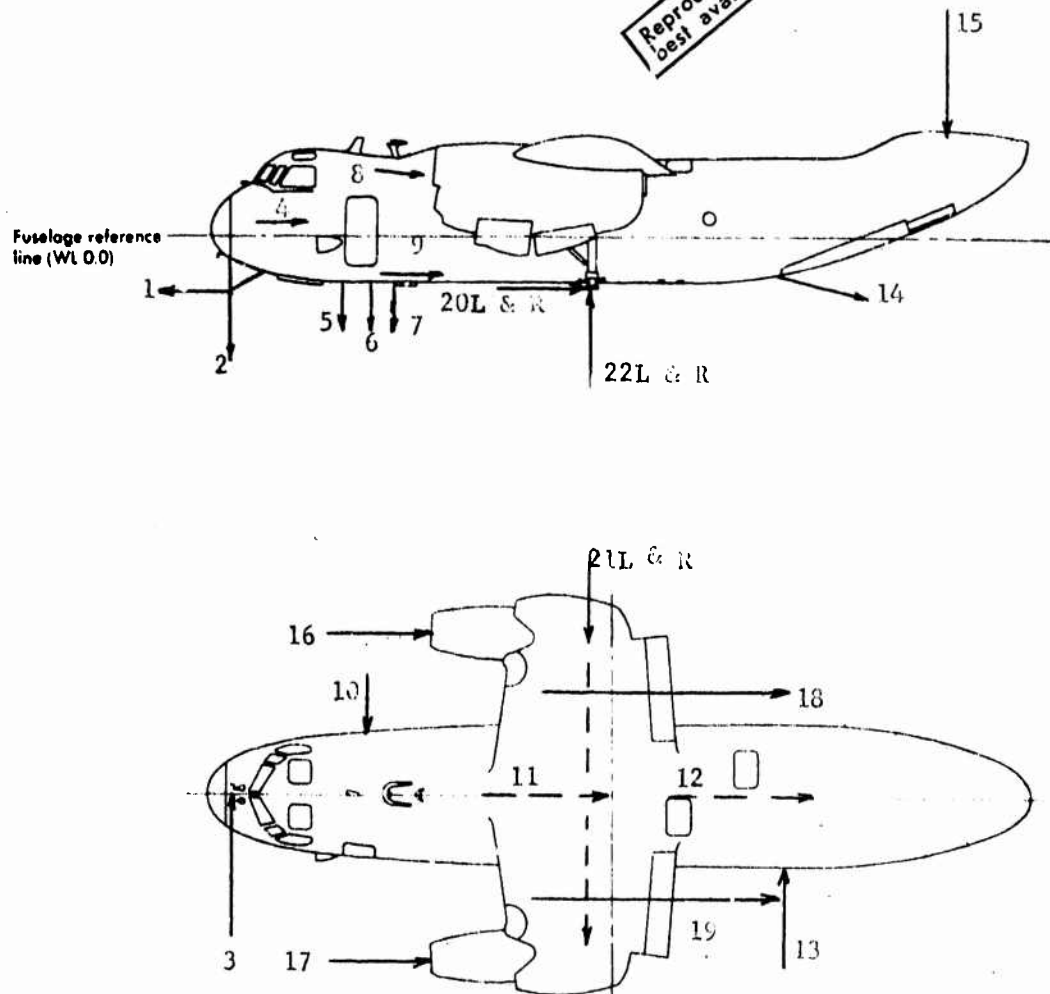


FIGURE 1 REFERENCE AXES AND SIGN CONVENTION

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Note: The numbers correspond to the load point numbers of table 1.

FIGURE 2 BALANCE DIAGRAM

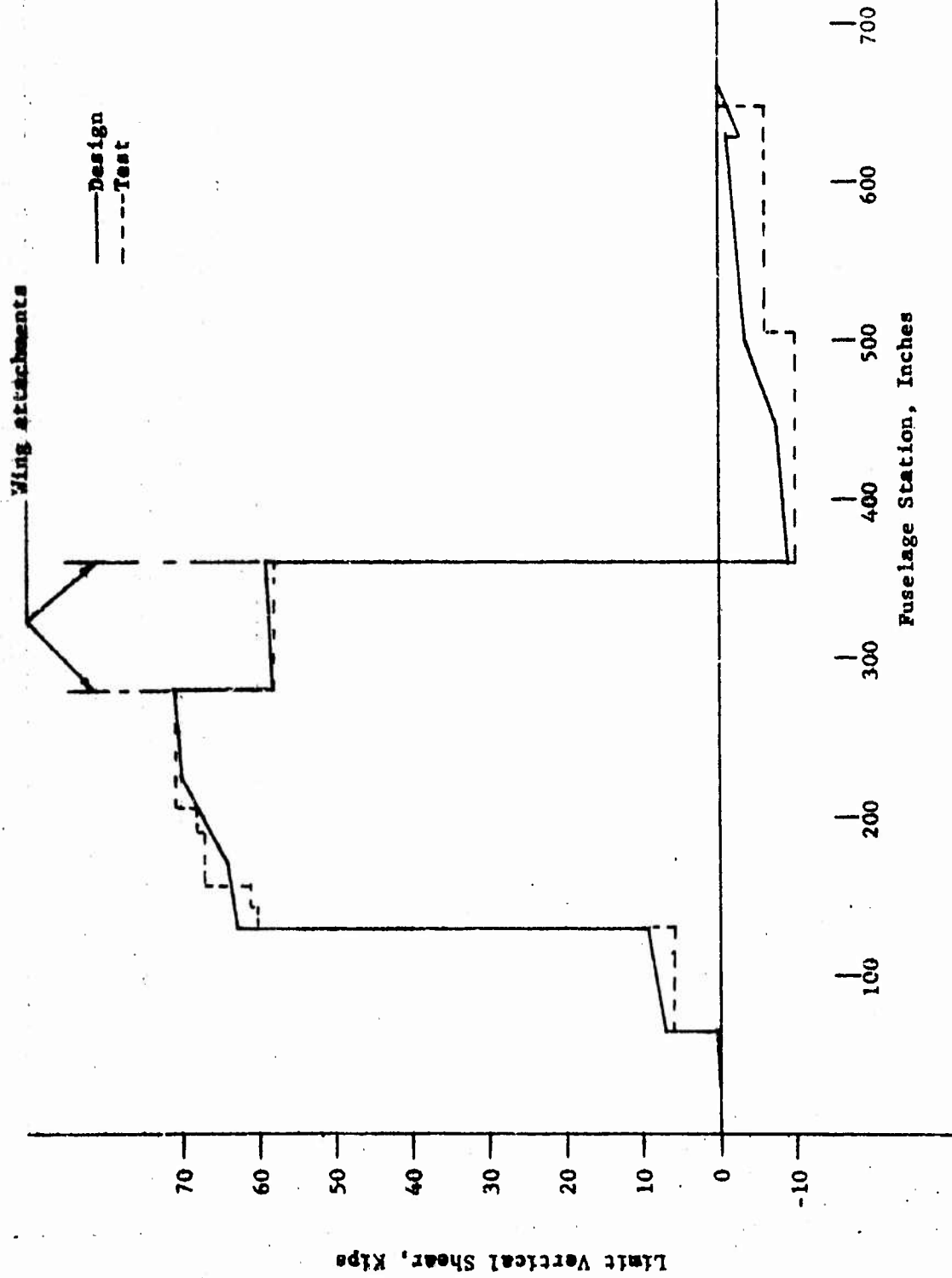


FIGURE 3-FUSELAGE VERTICAL SHEAR DISTRIBUTION

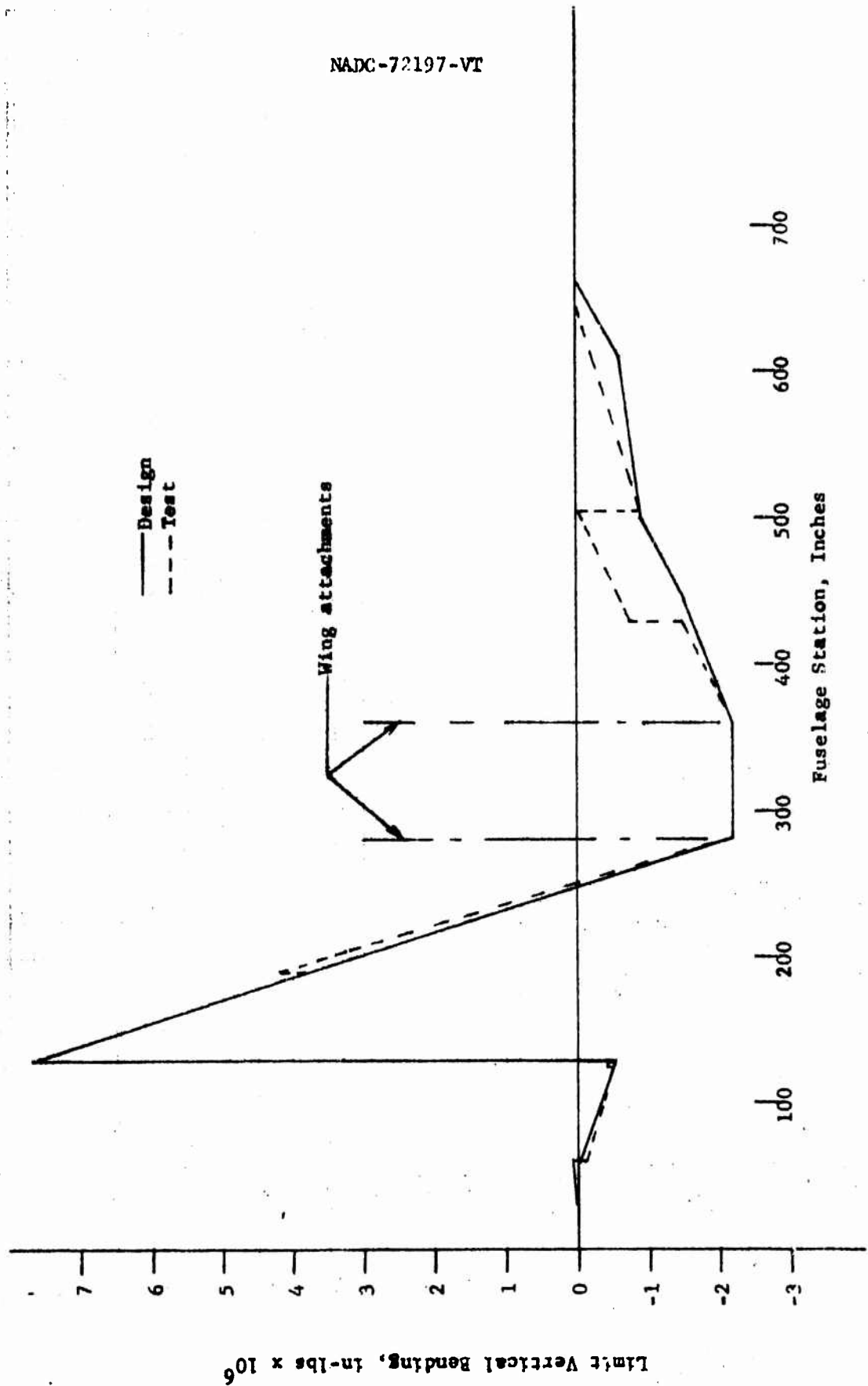


FIGURE 4-FUSELAGE VERTICAL BENDING MOMENT DISTRIBUTION

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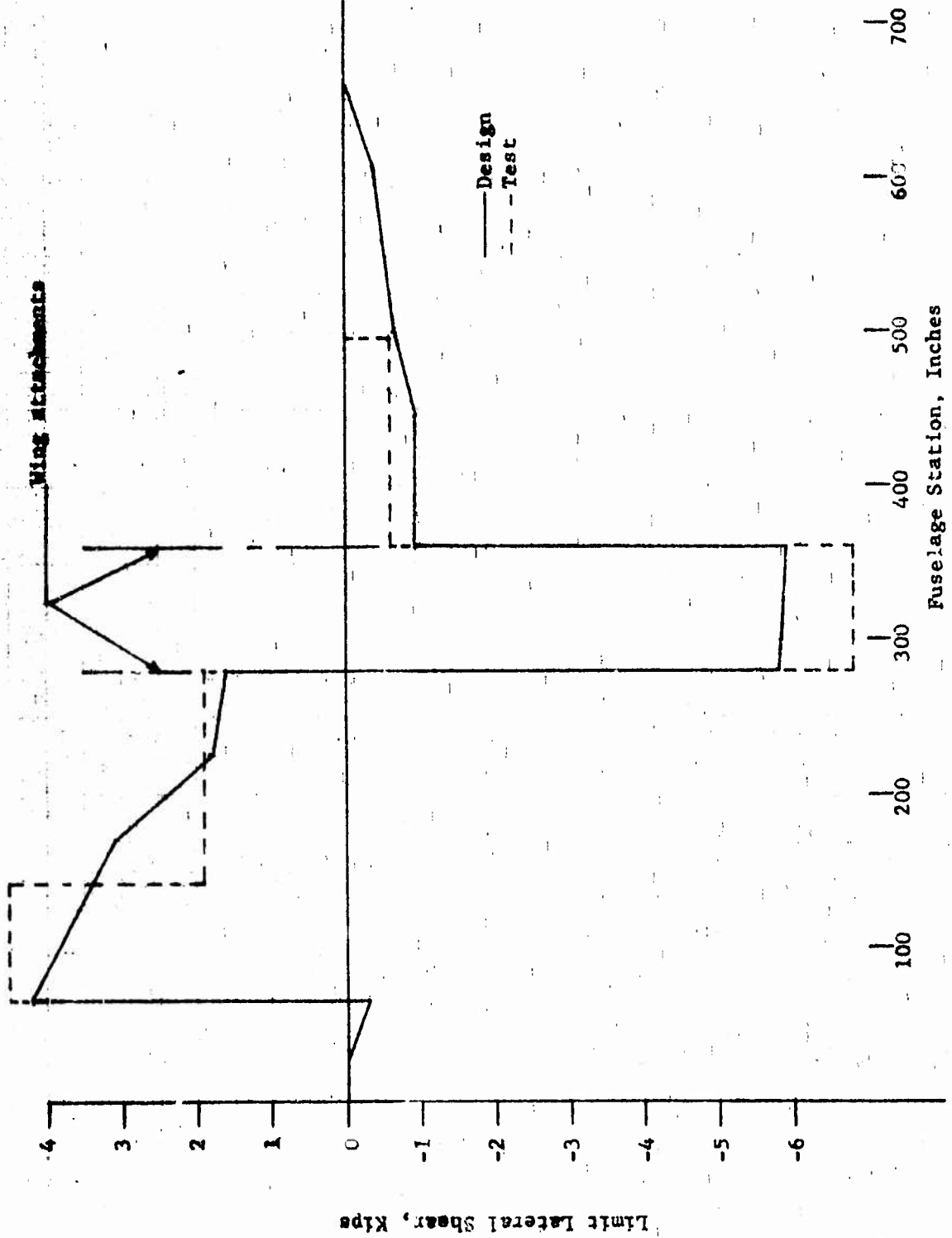


FIGURE 5-FUSELAGE LATERAL SHEAR DISTRIBUTION

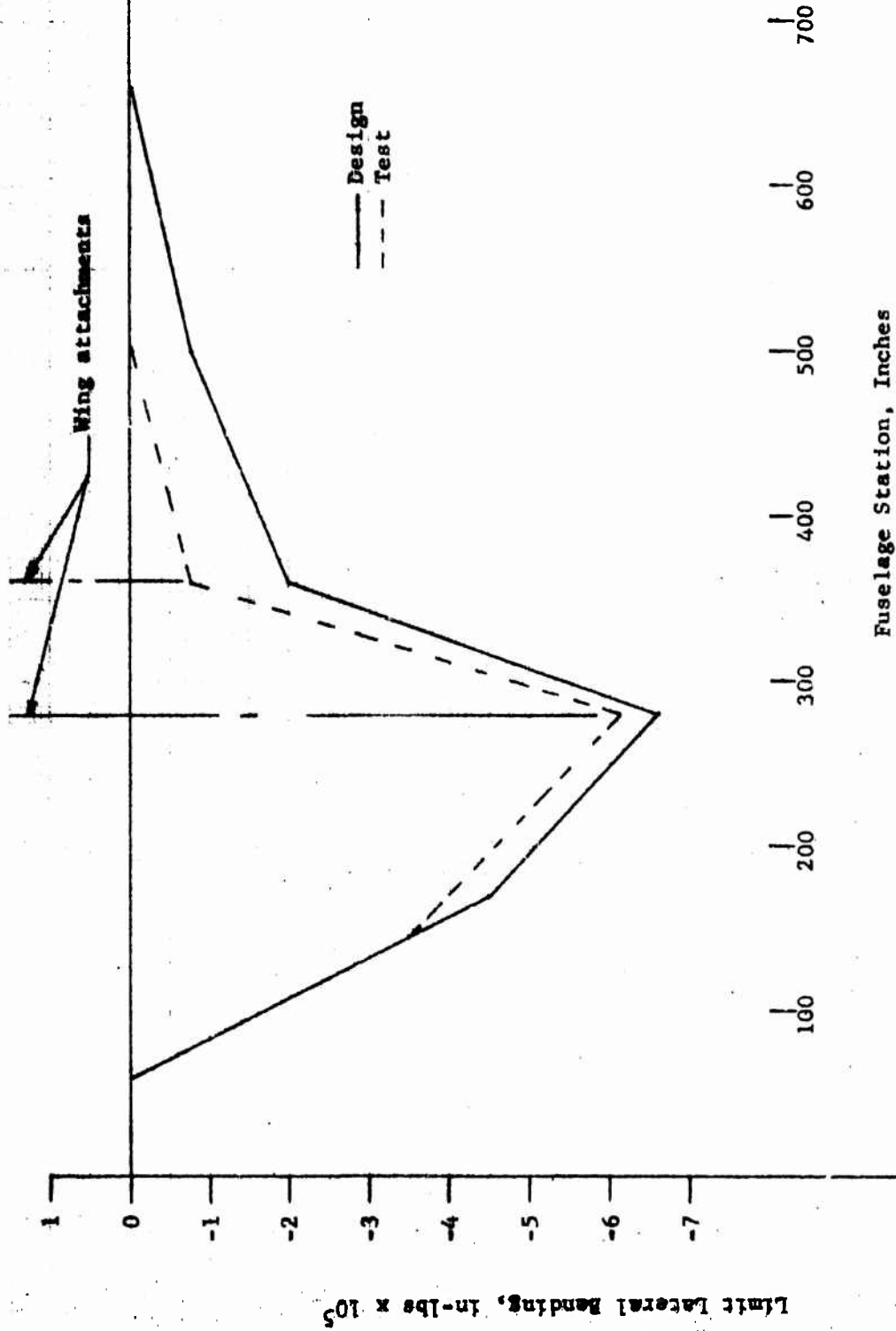


FIGURE 6-FUSELAGE LATERAL BENDING MOMENT DISTRIBUTION



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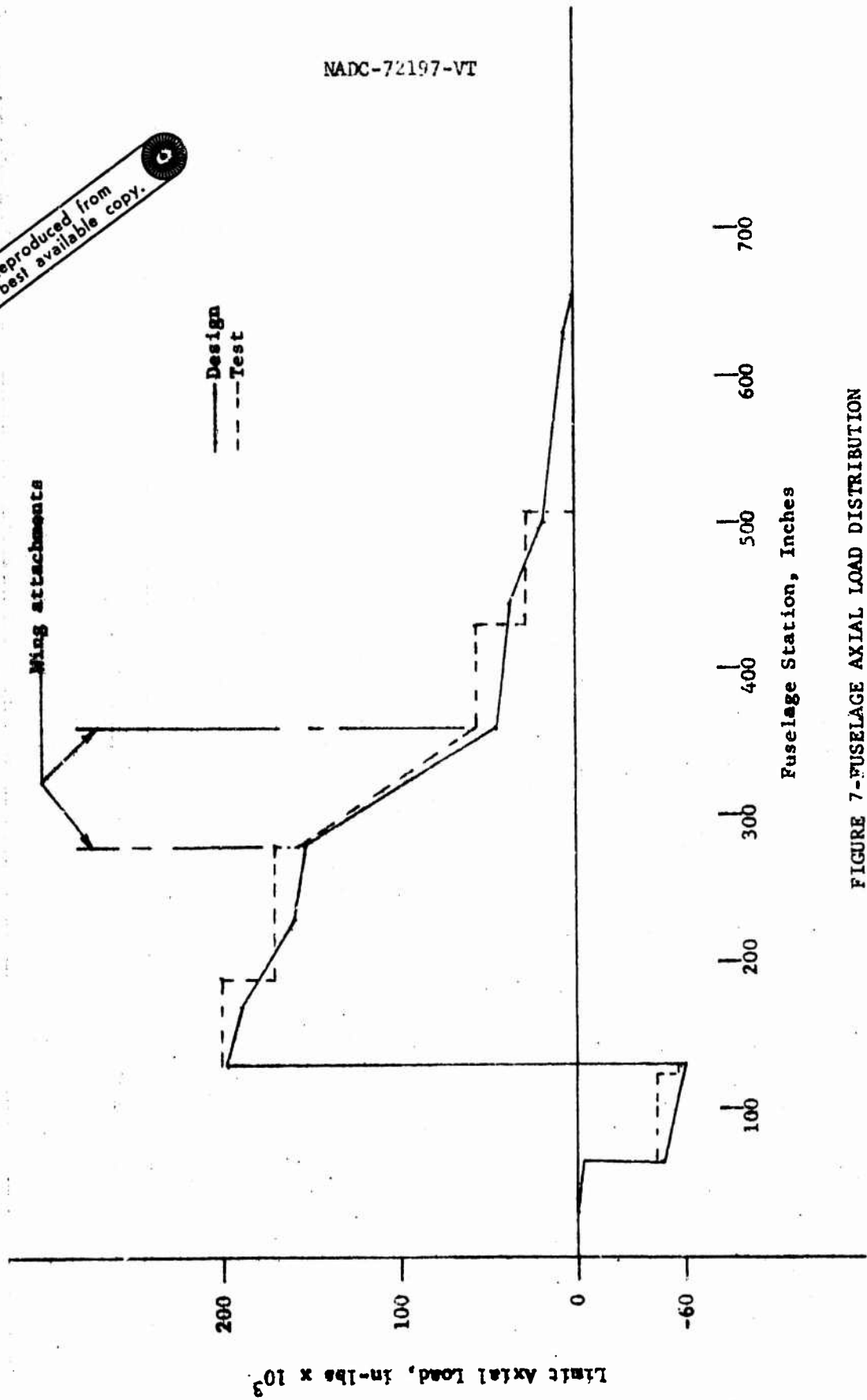


FIGURE 7-FUSELAGE AXIAL LOAD DISTRIBUTION

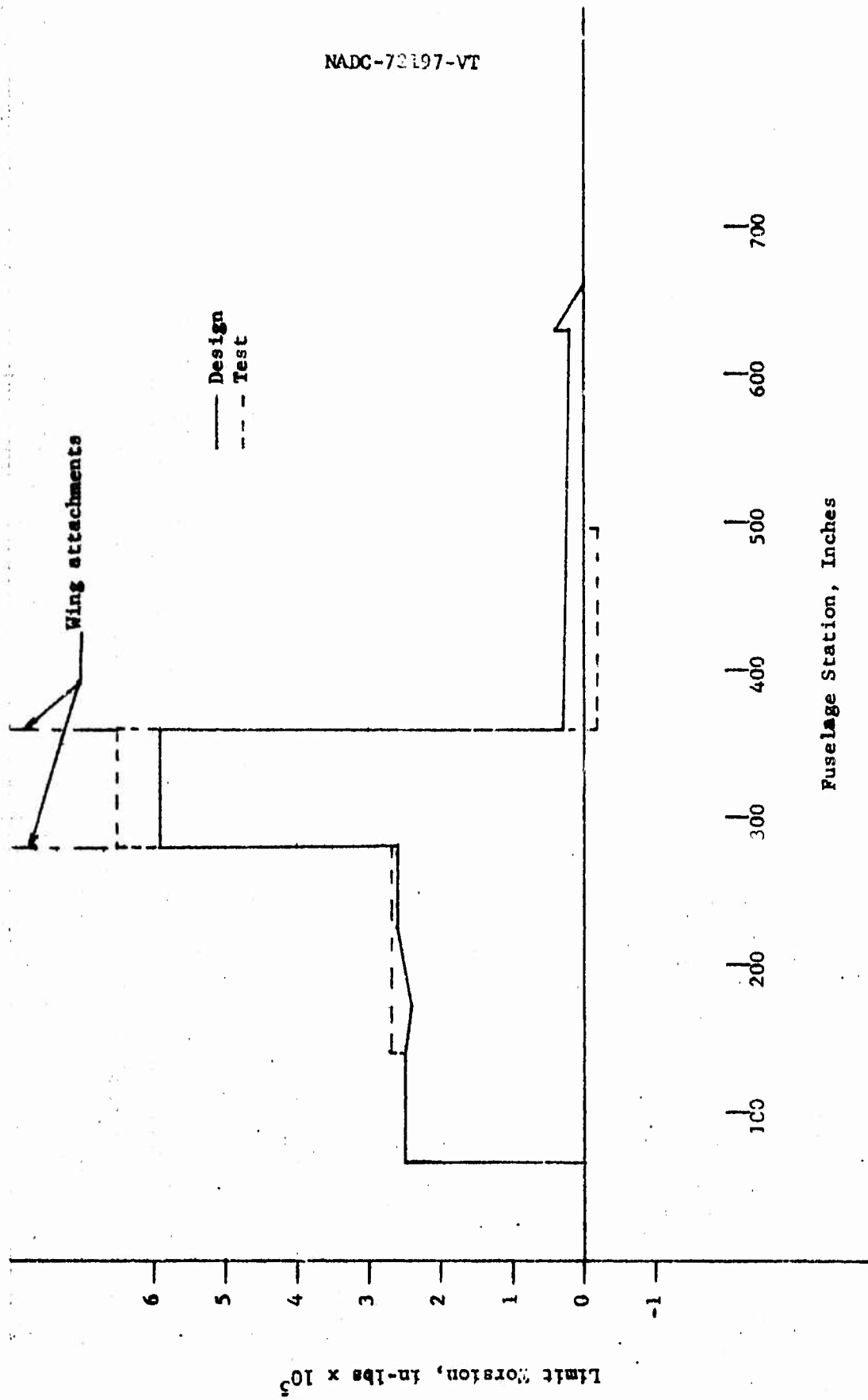


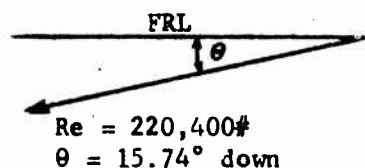
FIGURE 8-FUSELAGE TORSIONAL MOMENT DISTRIBUTION

**TABLE 1 - TEST LOADS - CATAPULT CONDITION 11Ca - SIDE LOAD RIGHT**

Load Point	Location, Inches			Applied Loads		
	X	Y	Z	X	Y	Z
1. Dummy Nose Gear	61.69	0	44.75	-212133	0	0
2. Dummy Nose Gear	61.69	0	44.75	0	-4493	0
3. Dummy Nose Gear	61.69	0	44.75	0	0	-59800
4. Cockpit Floor	125.00	0	109.00	+10666	0	0
5. Fwd Fuselage	143.75	0	100.00	0	0	-1200
6. Fwd Fuselage	157.50	0	100.00	0	0	-5960
7. Fwd Fuselage	205.50	0	100.00	0	0	-2500
8. Fwd Fuselage	190.50	0	153.50	+14822	0	-1332
9. Fwd Fuselage	190.50	0	75.00	+16016	0	0
10. Fwd Fuselage	143.75	0	108.65	0	+2620	0
11. Cargo Cage	282.50	0	96.36	+13668	0	0
12. Cargo Cage	430.50	0	128.00	+25733	0	0
13. Aft Fuselage	495.50	0	67.00	0	-578	0
14. Arresting Hook	507.50	0	72.00	+29569	0	-3670
15. Tail	647.00	0	100.00	0	0	-6132
16. Right Engine Mt	365.19	-126.26	141.64	+12649	0	0
17. Left Engine Mt	365.19	126.26	141.64	+12649	0	0
18. Right Wing	365.19	-73.31	155.30	+34666	0	0
19. Left Wing	365.19	73.31	155.30	+34666	0	0
Reaction Loads						
20L. L. Main Gear	349.58	126.26	76.84	+6165	0	0
20R. R. Main Gear	349.58	-126.26	76.84	+862	0	0
21L. L. Main Gear	349.58	126.26	76.84	0	+1225	0
21R. R. Main Gear	349.58	-126.26	76.84	0	+1225	0
22L. L. Main Gear	349.58	126.26	76.84	0	0	+41220
22R. R. Main Gear	349.58	-126.26	76.84	0	0	+39374

**Notes:**

- The X and Z loads applied to the dummy nose gear will be applied as the following resultant load:



This load is the resultant of the catapult tow link loads and wheel axle loads.

- When the nose gear side load is applied to the left the loads at load points 2, 10, 13, 21L and 21R reverse direction.